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EQUIVALENCE CLASSES GENERATED BY SEQUENCE TRAINING

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In Experiment 1, 3 adult females were taught with verbal instructions and contingencies to select, in sequence, three arbitrary visual stimuli from an array of five stimuli. After four different sequences were taught, match-to-sample tests assessed emergent conditional relations among all stimuli that had been selected in the same order in the sequences. Subjects' performances indicated development of four stimulus classes, three based on ordinal position and one based on nonselection. Next, match-to-sample training established conditional relations between each of four novel figures and one member of each of the ordinal stimulus classes. Tests confirmed that the classes were equivalence classes, each expanded by one new member. In subsequent sequence tests, the new stimuli were selected in a sequence that was consistent with ordinal class membership. Experiment 2 replicated Experiment 1 with 2 different adult females, but the verbal instructions were omitted. Results were similar to Experiment 1, except that extensive review and retesting were required before expansion of the ordinal classes with the novel figures was observed.

Key words: equivalence classes, sequences, match to sample, grammatical elements, syntactical classes, instructions, touch screen press, college students

The emergence of the equivalence of stimuli from conditional relations among the stimuli is a well-documented and reliable phenomenon. Since the initial demonstration by Sidman (1971), numerous replications involving a wide range of subjects, procedures, and stimuli have been published. In general, these studies have demonstrated that after specific conditional relations among several dissimilar stimuli have been demonstrated, other relational properties often emerge without direct training: *symmetry,* in which each demonstrated sample–comparison relation is reversed; and *transitivity,* demonstrated when two stimuli that were previously related only indirectly through their relation to a third common stimulus are related to one another on tests. An additional requirement for inferring equivalence is evidence of the property of *reflexivity*: Each stimulus must be related conditionally to itself, shown by generalized identity matching (Sidman et al., 1982; Sidman & Tailby, 1982). When these relational properties have been demonstrated, indicating that an equivalence class has developed, the various stimuli have proven substitutable for one another in a variety of situations. It has been suggested that the subject's behavior with respect to members of an equivalence class supports the inference that each stimulus serves as the referent for, or has the same meaning as, every other member of the class (e.g., Sidman, 1971, 1986). Further, the demonstration of untrained equivalence relations has been likened to the novel recombinations of the kinds of behavior that characterize human language. Such logic has led some authors (e.g., Fields, Verhave, & Fath, 1984; Sidman, 1986; Wulfert & Hayes, 1988) to assert that the stimulus equivalence paradigm provides a means to conduct functional analyses of complex language behavior.

A possibility that bears investigating is that stimuli (e.g., words) that occur in the same

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ordinal position in several different sequences (phrases or sentences) might constitute an equivalence class. The initial test of this possibility was reported by Lazar (1977). Adults learned to point to first one and then the other of two stimuli in each of four pairs. Next, subjects responded on probe trials consisting of two stimuli, one of which the subject had been trained to point to first and the other second, but each from different training pairs. When subjects responded to these "crossover" pairs in the same first–second order as they occurred in the original training pairs, Lazar concluded that the sequence training had established a class of "first" and a class of "second" stimuli. Match-to-sample procedures were then used to train subjects to relate a novel comparison stimulus to a sample from the first-position stimuli and another novel comparison to a sample from the group of second-position stimuli. Next, sequence tests were conducted with the new stimuli. Two of 3 subjects responded on these sequence tests in a manner that suggested that classes of "first" and "second" stimuli had developed from the original sequence training, that the match-to-sample training had succeeded in adding one new member to each sequence class, and that the sequence function had transferred to the new class members.

Conclusions about sequence class development based on the Lazar (1977) study are tempered by the fact that the sequences involved only two stimuli in a two-position sequence. Once the subject indicated which stimulus was "first," only one stimulus remained and was necessarily designated "second." Subjects might not have actually learned two ordinal classes; the "second" stimuli might have been treated as a class simply because they were the ones that were left after a response had been made to the first member of each pair. In addition, the Lazar (1977) study preceded Sidman's formal specification of the requisite tests for equivalence classes (Sidman et al., 1982; Sidman & Tailby, 1982) and did not assess whether the relations taught with the match-to-sample procedures had the properties of reflexivity, symmetry, and transitivity.

In the present study, subjects were taught to arrange sets of three abritrary visual stimuli, out of arrays of five stimuli, into left-to-right sequences on a computer screen. Following training on four sequences, several tests were used to determine whether stimulus classes based on position in the sequences had developed and whether the classes were equivalence classes. Tests were also conducted to determine whether new stimuli added to each class would be put in sequence according to the ordinal position of the original class members. Thus, the present experiments tested and extended the sequence-class logic suggested by Lazar (1977) by adding several features: (a) a three-position sequencing task; (b) the presence of distractor stimuli on sequencing trials to reduce the constraints of the forced-choice procedure that exist in two-position, two-stimulus sequencing tasks; (c) comprehensive tests for equivalence class development on the basis of ordinal position; and (d) tests for transfer of ordinal functions to new members of equivalence classes. In addition, these experiments permitted some comparisons between performances of subjects who received instructions describing the stimulus relations to be learned (Experiment 1) and subjects who received minimal instructions (Experiment 2).

EXPERIMENT 1

METHOD

Subjects

Three adult females, recruited through personal contact, volunteered as subjects. The first was a housewife; the others were first-year graduate students. All reported that they had completed at least one undergraduate course in psychology. Their ages and undergraduate degrees were: LJ, 28, German education; CM, 33, business; and KJ, 24, psychology. All spoke English as a second language. They were not acquainted and were instructed not to discuss the research with anyone. Subjects were never present in the experimental setting at the same time.

Apparatus

An Apple IIe® microcomputer system with a monochrome monitor, a Personal Touch Touchwindow® (touch sensitive screen), an Applied Engineering Timemaster II HO® clock card, a printer, and specially designed software controlled the experiments (stimulus presentations, timing, and data collection, storage, analysis, and printing). Subjects sat before

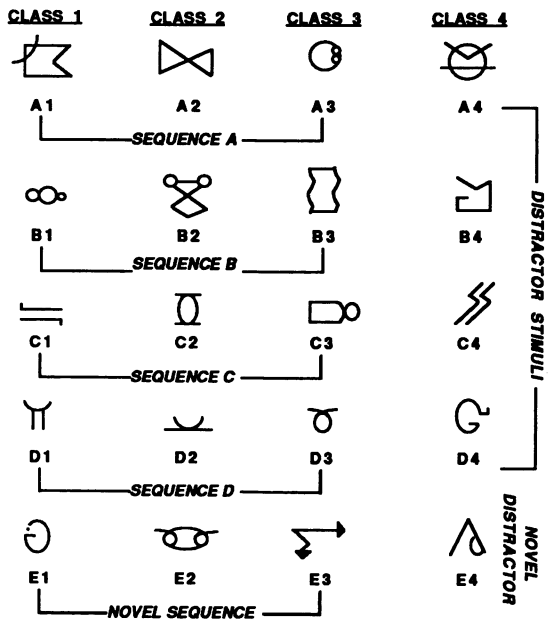

Fig. 1. Stimuli used in training and testing, Phases 2–6, in Experiments 1 and 2.

the monitor and responded to stimuli by touching the screen.

Stimuli

Twenty figures, drawn via the computer's high resolution graphics, served as stimuli. Each occupied an area about 3.3 cm by 2.7 cm on the screen. As shown in Figure 1, there were four potential classes of stimuli, numbered 1 through 4, with five stimuli per class, lettered A through E. Each stimulus is designated by letter and number for ease of identification.

Operation of the Apparatus

Separate computer programs presented training and testing opportunities for creating stimulus sequences and for matching to sample. Sequence trials began with five stimuli displayed in an unsystematic arrangement in eight possible locations in the upper two thirds of the monitor screen, as shown in the upper panel of Figure 2. A horizontal line separated the top and bottom portions of the screen display. When a subject touched a stimulus, it disappeared from the top display and reappeared in the lower left portion of the screen. The next stimulus touched moved to a position to the right of the previously touched stimulus

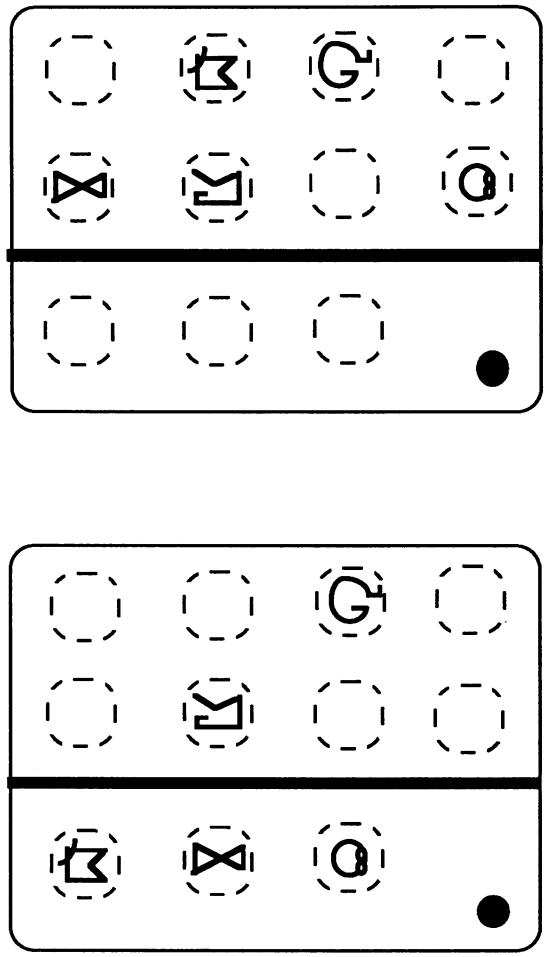

Fig. 2. Screen display at onset of a representative sequencing trial (top panel) and with a sequence completed (bottom panel). A touch to a stimulus caused the stimulus to appear to move from its position on the top of the screen to a position in the sequence at the bottom of the screen. The black dot indicates the position of the marker (a penny) that subjects touched to indicate that a sequence was completed.

on the bottom of the screen. After a stimulus was positioned in the lower area of the screen, the subject could touch it again to return it to the upper display and could touch another stimulus for placement in the sequence position. This procedure continued until three stimuli were arranged in left-to-right order along the bottom of the screen (see the lower panel in Figure 2). The subject then touched a marker (a penny) on the lower right corner of the screen to indicate sequence completion. In training conditions (Phases 1 and 2, de-

scribed below), the trial completion response was followed by a computer-generated jingle or buzzer of approximately 1-s duration, indicating a correct or incorrect sequence, respectively. During Phase 6 tests for untrained sequences, no programmed consequences followed trial completion responses. Trials were separated by a 4-s interval. The positions of the five stimuli that started each trial were randomized from trial to trial.

Match-to-sample trials began when a stimulus (the sample) appeared in the center of the monitor screen (the horizontal line and marker were not present). A response to the sample was followed immediately by the onset of two comparison stimuli, one on each side of and parallel to the sample such that the center of each comparison stimulus was 7.2 cm from the center of the sample stimulus. The sample remained in view throughout the trial. A response to a comparison resulted in the removal of all stimuli from the screen for 2 s. During match-to-sample training in Phase 4, correct selections of comparison stimuli produced the computer-generated jingle and incorrect selections produced the buzzer. In match-to-sample test phases (3 and 5), selections had no programmed consequences except removal of all stimuli and presentation of the next sample following the 2-s intertrial interval.

Setting and Sessions

All training and testing were conducted in an office (3 m by 4 m) containing office furniture and the computer apparatus. An experimenter prepared the computer, provided brief instructions to the subject, and remained in the room but out of sight while the subject performed the experimental tasks. Subjects and experimenters were instructed that no conversation was permitted when experimental tasks were being presented unless a technical problem occurred. Sessions were conducted 5 days a week for 60 to 90 min each day. Each session consisted of exposure to several sets of training or testing trials, each set consisting of either 12 sequencing trials or 16 match-to-sample trials. The number of sets completed per session ranged from 6 to 24 and varied unsystematically across individuals and sessions as a function of session length, type of task, and each subject's pace of responding. All 3 subjects completed the experiment within 20 sessions (3 to 4 weeks).

Criteria for Condition Changes

Subjects' performances were required to meet a criterion of 90% correct for two consecutive sets of trials during training conditions with programmed consequences following every trial. In addition, when multiple sequences or conditional relations were trained concurrently, performance on each sequence and conditional relation had to meet the 90% criterion. Next, the probability of consequences on each trial was reduced to .20 and then to 0. The same criterion had to be met at each of these consequence probability levels before the subject progressed to a testing condition. The criterion for determining that tested conditional relations were performed reliably was also 90% or better "correct" (congruent with predicted emergent performance) for two consecutive test sets. The criterion on the test for transfer of ordinal function (Phase 6, described below) was 90% or better congruent with transfer for four consecutive test sets.

Overview of Procedural Phases

All subjects experienced the same general procedures, with variations (reviews and retests) determined by individual performance. The sequence of conditions is shown in Table 1 and outlined here. Phase 1 was used to familiarize the subjects with the sequencing task by training them to touch three block-letter stimuli (of five available on each trial) in alphabetical order. Two sequences of three letters were trained. Phase 2 was used to train four sequences of three stimuli each, using the arbitrary visual stimuli shown in Rows A through D of Figure 1. In this sequence training, the stimuli in the column labeled "Class 1" in Figure 1 occupied the first position in correct sequences, stimuli in "Class 2" occupied the second position, stimuli in "Class 3" occupied the third position, and the stimuli in "Class 4" were distractors that were never selected in correct sequence production. Thus, stimuli from different sequences that had the same function in their respective sequences could comprise a class, as could the stimuli never selected. Phase 3 tested for the emergent conditional relations among stimuli that would show the development of these classes based on ordinal position and nonselection.

Ordinal classes are one of many kinds of stimulus classes; they may or may not be equivalence classes. Testing for the emergence of all

Table 1

Sequence of phases in Experiments 1 and 2 with the number of training and test sets administered per phase with each subject.

Phase	Number of training or test sets				
	Experiment 1 subjects			Experiment 2 subjects	
	LJ	CM	KJ	GM	CK
1. Pretrain sequences with block letters	3	3	2	3	12
2. Train sequences A–D with experimental stimuli	22	17	20	17	20
3. Test for ordinal classes and distractor class[a]	34	27	26	59[b]	45
	29	22	22	33	41
	26	14	13	14	—
4. Train ED relations to expand the classes[c]	7	7	7	6	9
				7	6
				6	11
					8
5. Test expanded classes for equivalence	16	14	15	61	91
6. Test for transfer of ordinal function to the E stimuli	9	9	8	9	8

[a] Data for Phase 3 are number of test sets (R1–R4 and OD1–OD8, shown in Table 3), number of mixed sequence sets given prior to each test set, and number of sequence review sets with feedback, respectively.
[b] Includes 26 sets of tests for reflexivity.
[c] Data for Phase 4 are number of training sets for initial acquisition (all subjects) and subsequent reviews (Subjects GM and CK).

possible conditional relations among ordinal class members may not be sufficient to demonstrate the defining properties of equivalence (cf. Sidman, Wynne, Maguire, & Barnes, 1989). For a definitive test of equivalence, a member of each class could be related via match-to-sample procedures to one of four different novel stimuli. Then, tests for emergent relations between each novel stimulus and the remaining members of the class could be conducted. Phases 4 and 5 provided the training and testing necessary for this additional rigor. Finally, in Phase 6 the subjects were given the opportunity to form sequences, in the absence of feedback, with the novel stimuli used in Phases 4 and 5. This tested whether the ordinal functions of the original members of the classes had transferred to the novel stimuli as a function of the match-to-sample training in Phase 4. The procedures used in each phase are described in more detail below. The numbers of training and test sets to which each subject was exposed in each phase are shown in Table 1. Results are presented after the procedures are described for each phase.

Procedures and Results

Phase 1: Pretrain Sequences with Block Letters

To familiarize the subjects with the sequencing task, sets of block letters were used in pretraining. On each trial, five letters appeared in an unsystematic pattern at the top of the screen. Three could be used to form an alphabetical sequence of three consecutive letters, and the other two were distractors. Two sequences were trained in this fashion in one 12-trial set. As shown in Table 2, one trial type presented a display with the letters A C D E Z; the correct sequence was C D E. The other trial type displayed the letters L P Q R I; the correct sequence was P Q R. Each trial type was presented six times per set, in unsystematic order. Before the first set, subjects were instructed as shown in Instruction 1 of the Appendix. The trial completion response was followed by a computer-generated jingle or buzzer of approximately 1-s duration, indicating a correct or incorrect sequence, respectively. Subjects required two or three sets to meet criterion (90% correct for two consecutive sets).

Phase 2: Train Sequences with Experimental Stimuli

Each of the four sequences trained consisted of three stimuli (shown in Figure 1), one from each of the three prospective classes, in the designated correct sequence (e.g., A1 A2 A3; see Table 2). Of the five stimuli available on each trial, three were from the correct sequence

Table 2
Trial types for sequence training in Phases 1 and 2.

	Correct sequence	Distractors
Phase 1 Training		
Pretraining sequences	C D E P Q R	A, Z I, L
Phase 2 Training		
Sequence A	A1 A2 A3	Two of A4, B4, C4, and D4
Sequence B	B1 B2 B3	Same as above
Sequence C	C2 C2 C3	Same as above
Sequence D	D1 D2 D3	Same as above
Sequence mix (with consequence probabilities 1.0, .20, and 0)	A1 A2 A3 B1 B2 B3 C1 C2 C3 D1 D2 D3	Same as above

and two (chosen unsystematically) were from prospective Class 4 (A4, B4, C4, D4) and served as distractors. Sequence A was trained first in 12-trial sets. The instructions used in pretraining were repeated before the first Sequence A set but were not repeated subsequently. Responses to the marker at the completion of correct and incorrect sequences produced the jingle and buzzer, respectively.

When the subject's performance reached criterion on Sequence A, Sequences B, C, and D were trained in succession. Then all four sequences were mixed in the same training set (see Table 2), each appearing three times in unsystematic order with consequences following every trial. When criterion was met, the probability of consequences was reduced to .20, preceded by the instructions shown as Instruction 2 in the Appendix. These instructions were not repeated after the first training set with the .20 probability of consequences. Once performance was maintained at criterion with the .20 consequence probability, the probability of consequences on each trial was reduced to zero, preceded by Instruction 3 (see Appendix). The subjects learned each sequence in two to six sets when it was trained separately and maintained criterion performance when sequences were mixed within a set and consequence probabilities were reduced to .20 and then 0.

Phase 3: Test for Ordinal Classes and Distractor Class

All testing for conditional relations was conducted with match-to-sample procedures. Each combination of a sample and two comparisons was defined as a trial type. All trial types for this phase are shown in Table 3. Trial types were presented in random order in 16-trial sets, with no trial type appearing more than three times consecutively. Each sample appeared an approximately equal number of times in each set, and each comparison appeared an approximately equal number of times as the correct and incorrect comparison. The position of the correct comparison (to the left or right of the sample) was unsystematic from trial to trial. No consequences except the intertrial interval followed any responses on test trials. Selections of the designated correct comparisons showed the conditional relations predicted by class formation based on ordinal position. Seclection of the other comparison indicated that such classes had not formed. The criterion for changing conditions was at least 90% correct responses (consistent with predicted relations) on all relations for two consecutive test sets, or a maximum of six consecutive administrations of a test set. After six test sets, if criterion had not been met but there was a clear improving trend (at least three consecutive sets with scores increasing), testing continued to criterion or until there was no further improvment.

The first tests administered in this phase were tests for the property of reflexivity (generalized identity matching) in relations among the stimuli used in sequence training (excluding pretraining stimuli). Although tests for reflexivity were not necessary for the demonstration of ordinal classes, they were essential to the subsequent demonstration that the ordinal classes were also equivalence classes. Their inclusion in this phase served that function and also served to introduce the match-to-sample procedures to the subjects. Four test sets were administered, each presenting four different trial types four times each in unsystematic order (see Test Sets R1 through R4 in Table 3). The first set was preceded by Instruction 4 (see the Appendix). Test sets were repeated until the subject's performance met criterion. All of the subjects performed on the tests for reflexivity virtually without error; therefore, these results are not presented here.

The next tests in this phase assessed whether the stimuli that occupied the same ordinal positions in the trained sequences were related conditionally to one another and whether the

Table 3

Phase 3 trial types for match-to-sample test sets for reflexivity (R) and for ordinal and distractor classes (OD).

Test set	Relations tested	Sample	Comparisons	
R1	Reflexivity with first position stimuli	A1	A1	A2
		B1	B1	B2
		C1	C1	C2
		D1	D1	D2
R2	Reflexivity with second position stimuli	A2	A2	A1
		B2	B2	B1
		C2	C2	C1
		D2	D2	D1
R3	Reflexivity with third position stimuli	A3	A3	A4
		B3	B3	B4
		C3	C3	C4
		D3	D3	D4
R4	Reflexivity with distractor stimuli	A4	A4	A3
		B4	B4	B3
		C4	C4	C3
		D4	D4	D3
OD1	AD, BD, CD Third position and distractors	A3	D3	D4
		B3	D3	D4
		C3	D3	D4
		A4	D4	D3
		B4	D4	D3
		C4	D4	D3
OD2	AD, BD, CD First and second positions	A1	D1	D2
		B1	D1	D2
		C1	D1	D2
		A2	D2	D1
		B2	D2	D1
		C2	D2	D1
OD3	AB, BA, AC, CA, BC, CB Third position and distractors	A3	B3	B4
		B3	A3	A4
		A3	C3	C4
		C4	A4	A3
		B4	C4	C3
		C4	B4	B3
OD4	Remaining AB, BA, AC, CA, BC, CB Third position and distractors	A4	B4	B3
		B4	A4	A3
		A4	C4	C3
		C3	A3	A4
		B3	C3	C4
		C3	B3	B4
OD5	AB, BA, AC, CA, BC, CB First and second positions	A1	B1	B2
		B1	A1	A2
		A1	C1	C2
		C2	A2	A1
		B2	C2	C1
		C2	B2	B1
OD6	Remaining AB, BA, AC, CA, BC, CB First and second positions	A2	B2	B1
		B2	A2	A1
		A2	C2	C1
		C1	A1	A2
		B1	C1	C2
		C1	B1	B2
OD7	DA, DB, DC Third position and distractors	D3	A3	A4
		D3	B3	B4
		D3	C3	C4
		D4	A4	A3
		D4	B4	B3
		D4	C4	C3
OD8	DA, DB, DC First and second positions	D1	A1	A2
		D1	B1	B2
		D1	C1	C2
		D2	A2	A1
		D2	B2	B1
		D2	C2	C1

Note: The designated "correct" comparison is shown as the first comparison in each pair.

stimuli that had been distractors on sequence training trials were likewise related. Because there were 48 possible trial types for these tests, six trial types were presented in each of eight different 16-trial sets, as shown in Table 3. Each trial type appeared two or three times in a set, varying unsystematically across sets. Because not all test sets could be presented at once, the test sets were ordered as follows: Some relations among the stimuli in the third sequence position (Class 3) and among stimuli that had been distractors (Class 4) were tested first (Test Set OD1); then tests for analogous relations from the first and second sequence positions (Test Set OD2) were presented. Subsequent tests (OD3 through OD8) evaluated all remaining posssible conditional relations, as shown in Table 3. Test Sets OD1 and OD2 presented the A, B, and C stimuli as samples and the D stimuli as comparisons. This simulated the multiple-sample single-comparison procedures that were shown to facilitate equivalence class development by Spradlin and Saunders (1986). No programmed consequences followed comparison selection in any of these tests. The decision to test the third position and distractor relations before the first and second position relations was made to avoid the possibility that testing first for relations among first-position stimuli might provide an additional cue that the correct relations were based on ordinal position (i.e., "first in sequences" and "tested first").

Prior to each test set (except reflexivity tests), subjects were exposed to a mixed set of the four trained sequences with no programmed consequences. No further instructions were given prior to these or any subsequent match-to-sample tests. If criterion performance was not demonstrated within six test sets with a

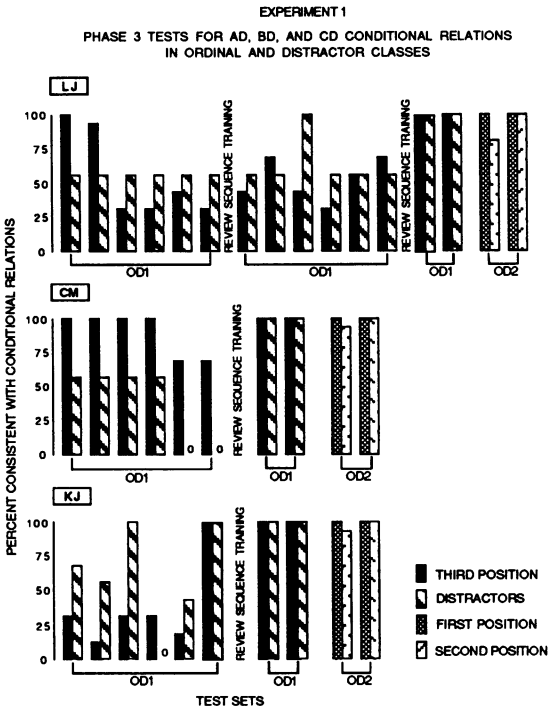

Fig. 3. Graphic respresentation of the subjects' performances in Phase 3 of Experiment 1 on tests for ordinal and distractor classes. Each pair of bars (or a bar and a 0) represents one 16-trial test set. Individual bars represent performance on all trials (6–9 total) in that test set involving stimuli from one sequence position or the distractors. Designations below the bars correspond to test sets in Table 3. Performances on the sets of mixed sequences without feedback that occurred before each test set are not shown.

particular set of relations, a review of sequence training was provided (i.e., all four sequences mixed, with per trial consequence probabilities 1.0, then .20, then 0), and the tests were readministered, beginning with the set that had not been performed to criterion.

The results of Test Sets OD1 and OD2 are shown in Figure 3. Each pair of bars in the graph represents performance on one 16-trial test set. The designations below the pairs of bars correspond to the test sets in Table 3. Individual bars summarize performance on the trial types involving stimuli from each sequence position that were presented on that test. For example, Test Set OD1 tested the relations A3D3, B3D3, and C3D3 two or three times each. The first bar of each pair for Test Set OD1 in Figure 3 shows the percentage of all third-position (Class 3) trials on which the subject's responses were congruent with those relations. The relations A4D4, B4D4, and C4D4 were also tested two or three times each in Test Set OD1. The second bar of each pair for that test set in Figure 3 shows the percentage of all trials on which those relations were demonstrated. Data for Test Set OD2 (Class 1 and Class 2 stimuli) are arranged similarly in Figure 3.

All of the subjects continued to perform at criterion on all of the sequence training sets (without feedback) that preceded the administration of each test set, but none of the subjects demonstrated conditional relations among the third-position and distractor stimuli immediately and consistently. Subjects LJ and CM initially matched third-position stimuli but not distractor stimuli to one another. By the third administration of Test Set OD1, LJ no longer matched third-position stimuli reliably. Subject CM no longer related third-position stimuli reliably after the fourth test; she also began selecting a third-position comparison every time a distractor stimulus was the sample. Subject KJ's performances on the distractor trials during the first series of Test Set OD1 were variable, but for most trials on which a third-position stimulus was the sample she selected a comparison that had been a distractor. On the sixth administration of Test Set OD1, however, KJ reliably matched all third-position stimuli and all distractor stimuli.

Because none of the subjects' performances on Test Set OD1 met criterion, each was given a review of sequence training. (Were it not for the decision to review the sequences with feedback after six below-criterion tests, Subject KJ might have met criterion on the next set without a review.) This review consisted of repeating Phase 2 exactly as it was presented originally (consequence probabilities of 1.0, .20, and 0). Subsequent to this review, Subject LJ's performance on Test Set OD1 varied unsystematically from test to test, but CM and KJ demonstrated all conditional relations among the third-position and distractor stimuli on all trials in the first retests after the sequence review. Following a second review of sequence training, LJ also demonstrated all conditional relations in Test Set OD1. All 3 subjects then demonstrated virtually all the AD, BD, and CD relations among stimuli in first and second positions (Classes 1 and 2) the first time they

Table 4

Trial types for training the ED relations in Phase 4.

Phase 4 training	Sample	Comparisons	
ED (with consequence probabilities 1.0, .20, and 0)	E1	D1	D2
	E2	D2	D1
	E3	D3	D4
	E4	D4	D3

Note: The designated "correct" comparison is shown as the first comparison in each pair.

were tested with Test Set OD2. All subjects' responses on tests for all remaining conditional relations among stimuli from all sequence positions and the distractors (Test Sets OD3 through OD8 shown in Table 3) demonstrated immediate and complete emergence of those relations. The results of these tests are not displayed graphically because there was only one error, by subject LJ on the last test set, across all of these tests.

The results to this point demonstrated that the subjects matched every member of each ordinal class to every other member of that class. These performances, however, did not demonstrate that the ordinal classes were also equivalence classes. To test equivalence directly, it was necessary to demonstrate the emergence of symmetry and transitivity from new conditional relations that were trained directly.

Phase 4: Train ED Relations to Expand the Classes

Match-to-sample procedures were used to teach a conditional relation between each of four novel stimuli (E1, E2, E3, and E4) and the D stimuli (D1, D2, D3, and D4), respectively (see Figure 1). The novel E stimuli served as samples and the D stimuli were comparisons, as shown in Table 4. Before the first training set, subjects were given the instructions shown as Instruction 5 in the Appendix.

Initially, programmed consequences were provided for every trial as described previously. When criterion performance was demonstrated, consequence probability was reduced to .20, preceded by Instruction 6 in the Appendix. Next, the probability of programmed consequences on each trial was reduced to zero. The instructions shown as Instruction 7 in the Appendix were given prior to the first such set. All 3 subjects learned the new conditional relations E1D1, E2D2, E3D3, and E4D4 in three training sets with 1.0 consequence probability and maintained criterion performance under reduced feedback and extinction conditions.

Table 5

Phase 5 test sets for equivalence classes (EQ).

Test set	Relations tested	Sample	Comparisons	
EQ1	AE, EA	A3	E3	E4
	Classes 3 and 4	E3	A3	A4
		A4	E4	E3
		E4	A4	A3
EQ2	BE, EB	B3	E3	E4
	Classes 3 and 4	E3	B3	B4
		B4	E4	E3
		E4	B4	B3
EQ3	CE, EC	C3	E3	E4
	Classes 3 and 4	E3	C3	C4
		C4	E4	E3
		E4	C4	C3
EQ4	AE, EA	A1	E1	E2
	Classes 1 and 2	E1	A1	A2
		A2	E2	E1
		E2	A2	A1
EQ5	BE, EB	B1	E1	E2
	Classes 1 and 2	E1	B1	B2
		B2	E2	E1
		E2	B2	B1
EQ6	CE, EC	C1	E1	E2
	Classes 1 and 2	E1	C1	C2
		C2	E2	E1
		E2	C2	C1
EQ7	DE	D1	E1	E2
	Classes 1, 2, 3, and 4	D2	E2	E1
		D3	E3	E4
		D4	E4	E3

Note: The designated "correct" comparison is shown as the first comparison in each pair.

Phase 5: Test Expanded Classes for Equivalence

A series of 16-trial test sets was administered to assess whether the conditional relations trained in the preceding phase were equivalence relations; that is, whether the stimulus classes based on ordinal positions were also equivalence classes. The first three test sets evaluated all possible relations between the E stimuli and other stimuli in the third-position and distractor classes, shown as Test Sets EQ1 through EQ3 in Table 5. These tests were direct tests for equivalence in that they were combined tests for the properties of sym-

Table 6
Phase 6 trial types for transfer of ordinal function test sets (TOF).

Test set	Training trials	Distractors	Test trials	Distractors
TOF1	A1 A2 A3 B1 B2 B3	Two of A4, B4, C4, D4, E4	E1 E2 E3	Two of A4, B4, C4, D4, E4
TOF2	C1 C2 C3 D1 D2 D3	Two of A4, B4, C4, D4, E4	E1 E2 E3	Two of A4, B4, C4, D4, E4

metry and transitivity (Sidman & Tailby, 1982). Three additional sets (EQ4 through EQ6) tested for equivalence among stimuli from the first and second ordinal classes. Next, tests to evaluate the symmetry of the previously trained ED relations were conducted (Test Set EQ7). Each test set was administered until criterion was met, or a maximum of six times. No further instructions were given to the subjects.

The results of Phase 5 are not displayed because virtually all responses by all 3 subjects were consistent with the development of four equivalence classes (at least 90% consistent on all trial types shown in Table 5). The only exception was Subject KJ's first performance on Test Set EQ1 (AE and EA relations in Classes 3 and 4), which was 75% consistent with equivalence. Thereafter, all her test performances were perfectly consistent with emergence of equivalence in all four classes. All subjects' performances on tests for symmetry of the trained ED relations were also 100% consistent with emergence of symmetry. The subjects' responses in this phase, coupled with their Phase 3 reflexivity performances, indicated that the three ordinal classes and the distractor class were also equivalence classes, because only equivalence could account for the emergence of all relations on tests (cf. Sidman et al., 1989).

Phase 6: Test for Transfer of Ordinal Functions to the E Stimuli

This phase evaluated whether the subjects would select the E stimuli in a sequence consistent with the ordinal functions of the members of their respective classes. Because the subjects had not been exposed to the trained sequences for some time, we elected to use trained sequences as the baseline into which test trials for Sequence E could be presented. Thus, six test trials for the new sequence E1 E2 E3 were interspersed with six trials of the previously trained sequences in each test set, as shown in Table 6. Test trials presented a display that included E1, E2, E3, and two stimuli from the distractor class (A4, B4, C4, D4, E4). Two different test sets were constructed: the first with probes inserted in a baseline of Sequences A and B, the second with a baseline of Sequences C and D (Test Sets TOF1 and TOF2 in Table 6).

Each test set was administered until four consecutive sets were completed with at least 90% of all responses on test trials congruent with the transfer of ordinal functions. Thus, the subjects had at least 24 opportunities to demonstrate the new sequence in each of two baselines. No further instructions preceded these tests, and no programmed consequences followed any sequence completion responses. If the ordinal functions developed in the first phase of the experiment transferred to the new members of the equivalence classes, then on these tests subjects were expected to arrange E1, E2, and E3 in that order and were expected not to place E4 in any sequence position.

Subjects CM and LJ produced the E1 E2 E3 sequence on only two and three test trials, respectively, in the first test set, but thereafter produced the new sequence on every test trial in four additional administrations of each test set. Subject KJ's performance on all test trials from the outset was consistent with transfer of ordinal functions to the new equivalence class members.

Discussion

This experiment extended sequence class or ordinal class logic and procedures beyond the two-position, two-stimuli case demonstrated in the Lazar (1977) study to sequencing performances involving three ordinal positions with extraneous stimuli always present when se-

quence responses were made. Three adults demonstrated the development of classes of "first," "second," "third," and "not selected" stimuli on match-to-sample tests. When a conditional relation between a novel stimulus and a member of each class was taught, test performances indicated that the classes were equivalence classes. Next, selection of the novel stimuli on sequence tests in the same order as other class members were selected during sequence training indicated that ordinal functions transferred to the novel stimuli via the match-to-sample training and testing.

The gradual emergence of conditional relations observed in Phase 3 among stimuli that served the same functions in sequences resembles the gradual emergence of untrained relations seen frequently in stimulus equivalence research (e.g., Lazar, Davis-Lang, & Sanchez, 1984; Saunders, Wachter, & Spradlin, 1988; Sidman, Kirk, & Willson-Morris, 1985; Sidman, Willson-Morris, & Kirk, 1986). For some subjects, untrained stimulus control appears to develop simply with retesting. There are several possible reasons that the expected performances did not emerge immediately in our Phase 3. Recall that the only instructions given to the subjects before their first exposure to the match-to-sample tests (reflexivity tests) were to select the figure that "goes with" the first figure seen on each trial and that there were no programmed consequences following test trials. All subjects performed nearly errorlessly on the reflexivity tests. This performance may have set the occasion for a subject to respond on the subsequent OD1 test on the basis of perceptual similarity. Alternatively, if the sequence training established relations based on *order* among stimuli within the sequences, then when a subject responded to a stimulus from the third position as a sample in Test Set OD1, the next response implied might have been to select a comparison that was formerly a distractor stimulus. That is, the distractor might "go with" the third-position stimulus because it was what remained on the screen after the third-position stimulus was selected in a sequence training trial. On the other hand, inclusion of distractor stimuli in sequences had been punished. Subjects appeared to discriminate quickly that the distractor stimuli did not "go with" any other stimuli during sequence training. Thus, when the subjects entered Phase 3 match-to-sample testing (Test Set OD1), their immediate histories may have provided them with several bases for relating stimuli from disparate sequences, including common functions in the sequencing tasks.

Given that several bases for responding were possible, why did the subjects ultimately respond in a manner consistent with control by conditional relations based on ordinal function? Did the Phase 3 testing for conditional relations AD, BD, and CD in the third-positon and distractor classes somehow "teach" the subjects to select comparison stimuli on this basis? Although the tests provided only the opportunity to respond with no new information, when sequence training and the tests were repeated the subjects may have inferred that they were not performing as the experimenter wished. The sequence of tests and review sets may have served an instructional function, selecting one kind of controlling relation from the several possibilities. Alternatively, because the subjects demonstrated the expected conditonal performances immediately after reviewing the trained sequences, the sequence review alone may have been sufficient to alter subsequent test performances, rather than additional experience with the test trials per se. It is unclear why a review of sequence training with feedback influenced subsequent test performance, however, when the 12-trial review of the sequences without feedback that preceded every test set apparently did not.

Whatever the explanation for the emergence of conditional relations among the third-position and distractor stimuli following sequence review, the same kind of control was demonstrated immediately with stimuli from the first and second sequence positions without further review (see Figure 3, far right bars). Thereafter, on Test Sets OD3 through OD8, all other conditional relations in the ordinal classes emerged without training. That is, classes were demonstrated by all subjects without explicit training of the conditional relations and without explicit verbal instructions regarding the ordinal basis for the classes. Next, simply training one new conditional relation per class led immediately to the expansion of the ordinal classes to include a fifth member and to the confirmation that the ordinal classes were equivalence classes.

Crossover tests of ordinal function (cf. Lazar, 1977), to determine whether members of

the ordinal classes controlled common responses in various sequence contexts, were not conducted. Such tests may have shown that the ordinal classes were functional classes (Goldiamond, 1966). However, the immediate transfer of the ordinal function to the new class members that had never been presented in a sequencing context (Phase 6) implied that the ordinal classes were functional classes. Whether ordinal classes, functional classes, and equivalence classes involve similar behavioral processes remains to be seen (cf. Sidman et al., 1989).

EXPERIMENT 2

Instructions to subjects may play an important role in both sequence acquisition and equivalence class development (cf. Wulfert & Hayes, 1988), but omitting instructions about procedures can also have profound effects (Baron & Galizio, 1983). Verbal instructions to subjects in Experiment 1 directed them to perform the sequencing tasks by placing three figures ". . . in order from left to right . . . ," and to ". . . touch the figure that goes with . . ." the sample on match-to-sample tasks (see Appendix). Would the training contingencies, in the absence of instructions that described the nature of the stimulus relations to be learned, produce similar outcomes? A second experiment with most verbal instructions omitted was undertaken to replicate the first and to address this question.

Method

Subjects

Two adult female volunteers were recruited whose demographics were similar to those of the participants in Experiment 1. Both were undergraduate students in interior design whose ages were 32 (GM) and 27 (CK). They had taken one and no undergraduate psychology courses, respectively. Their respective participation in the study did not overlap. Both spoke English as a second language. They completed about the same number of training and testing sets per 60-min session as did the subjects in Experiment 1 and required about the same amount of time to complete the experiment (3 to 5 weeks).

Procedures and Results

This experiment was conducted in a different setting than Experiment 1: a sound-attenuated, temperature-controlled room, 2.7 m by 3.3 m, containing three tables, two chairs, and the apparatus described for Experiment 1. All other conditions and procedures were identical to those of Experiment 1, with the following changes: To start the subject's first session in Phase 1, the experimenter prepared the computer and, with the subject seated before the apparatus, said, "Touch one." If the subject did not touch a stimulus within 10 s, the instruction was repeated. After the subject touched a stimulus, the experimenter said, "Touch another one." This was repeated until three stimuli were arranged in the lower portion of the screen (refer to Figure 2), at which point the experimenter said, "Touch the penny" (the sequence completion marker). If the jingle sounded after the subject touched the marker, the experimenter said, "That means correct"; if the buzzer sounded, the experimenter said, "That means incorrect." The experimenter watched the next trial to see that the subject performed the task. If she did not, the above instructions were repeated. In no case were the instructions given more than twice, and they were not repeated at any other point in the experiment.

When the sample stimulus for the first trial of the first match-to-sample test set (reflexivity test) appeared on the monitor screen, the experimenter said, "Touch it." If the subject did not touch the sample within 10 s, the instruction was repeated. After the subject touched the sample and the two comparisons appeared, the experimenter waited 10 s for the subject to make another response. If she did not touch the screen, the experiment said, "Touch again," and waited for the subject to touch a comparison (additional touches to the sample at this point had no effect). One more trial was observed and instructions were repeated if necessary, but after the second trial the instructions were not repeated and the experimenter left the room. The instructions were not repeated at any other point in the experiment.

Phases 1 and 2: Pretraining and Training Sequences A through D with Experimental Stimuli

Subject GM learned the pretraining sequences quickly (three sets), whereas Subject CK required 12 sets. These subjects required three to five sets to reach criterion on each of the sequences when they were trained separately and maintained criterion performance

with all sequences mixed and consequence probabilities reduced (see Table 1 for the numbers of sets required in each phase for each subject in Experiment 2).

Phase 3: Test for Ordinal Classes and Distractor Classes

Subject CK performed at criterion on reflexivity tests, but GM's initial performances ranged from 0% to 69% and varied considerably over a total of 23 test sets. She received two 16-trial sets of reinforced (but unstructed) identity matching trials with nonexperimental stimuli, followed by a repeat of the unreinforced test sets with experimental stimuli. These retest sets were completed without error.

On the first six administrations of Test Set OD1 (see Table 3), GM's performances ranged from 37.5% to 56% consistent with emergence of the AD, BD, and CD relations, with no reliable differences between third-position and distractor trial types. After one review of sequence training, GM's performance on Test Set OD1 improved from 56% on the first postreview test set to 100% on the second and third administrations. Subsequently, her responses on all tests for the remaining conditional relations (Test Sets OD2 through OD8, Table 3) were 97% to 100% consistent with ordinal class formation.

Although CK's initial performances on Test Set OD1 were below chance and variable, she began showing improvement with the fourth administration and continued improving simply with repeated testing, so that by the 14th administration the AD, BD, and CD relations among third-position and distractor stimuli were demonstrated on 100% of the test trials. The procedural rule that we had imposed on the other subjects—to review sequence training after six test sets below criterion—was not followed in this case because CK's performance improved with successive test sets. Performances on Test Set OD2 were 75%, 94%, 100%, and 94% consistent with the development of the analogous relations among first-position and second-position stimuli. Criterion was met within three to six administrations of all remaining test sets (OD3 through OD8).

Phase 4: Train ED Relations to Expand the Classes

These subjects required two (GM) and five (CK) training sets to reach criterion on the new conditional relations E1D1, E2D2, E3D3, and E4D4 and maintained criterion performance under reduced feedback and extinction conditions.

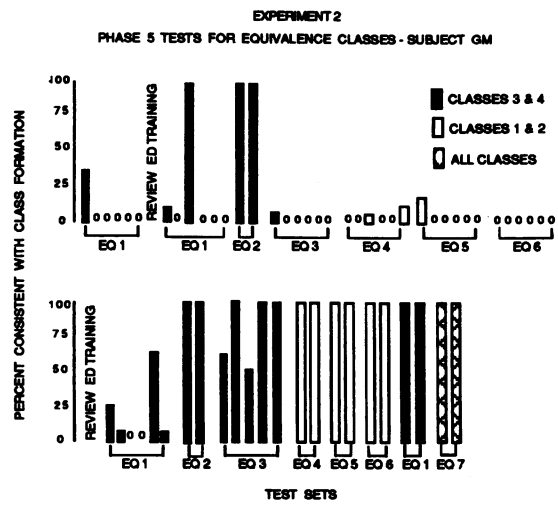

Fig. 4. Graphic representation of Subject GM's performances in Phase 6 of Experiment 2 on tests for equivalence (AE, EA, BE, EB, CE, EC) and symmetry (DE) in four classes following ED training. Each bar or 0 represents one 16-trial test set with four relations presented four times each. Designations below the bars correspond to test sets in Table 5.

Phase 5: Test for Expanded Classes Based on Equivalence

Figures 4 and 5 show the subjects' performances on tests for equivalence relations among the E stimuli and every other member of the four ordinal classes (see Table 5 for trial types). Unlike the subjects in Experiment 1, neither of these subjects demonstrated immediate, complete equivalence class development after learning to relate one new stimulus conditionally to one member of each ordinal class. As the top panel of Figure 4 illustrates, GM consistently related the B and E stimuli in Classes 3 and 4 (Test Set EQ2) after one review of ED training, but consistently failed to relate the E stimuli to any other stimuli in any class. Following a second ED review (Figure 4, lower panel), performances on tests for the AE and EA relations in Classes 3 and 4 (Test Set EQ1) were variable, wereas the BE, EB, CE, and EC relations in those classes (Test Sets EQ2 and EQ3) were demonstrated to criterion. Responses on all retests were then 100% consistent with development of equivalence relations in Classes 1 and 2 (Test Sets EQ4 through

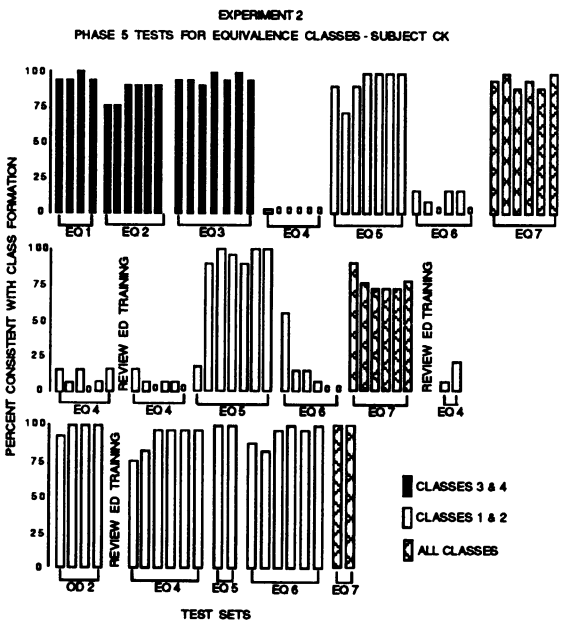

Fig. 5. Graphic representation of Subject CK's performances in Phase 6 of Experiment 2 on tests for equivalence (AE, EA, BE, EB, CE, EC), symmetry (DE), and conditional relations (AD, BD, CD) in four classes following ED training. Each bar or 0 represents one 16-trial test set with four relations presented four times each. Designations below the bars correspond to test sets in Table 5.

EQ6), followed by criterion performance on two readministrations of Test Set EQ1 and on tests for symmetry of the trained conditional relations (Test Set EQ7).

Subject CK's equivalence test results are shown in Figure 5. Her initial performances demonstrated near-complete emergence of equivalence relations among stimuli in Classes 3 and 4 (Test Sets EQ1 through EQ3), but only the BE and EB relations emerged in Classes 1 and 2 (Test Set EQ5). Symmetry test scores (Test Set EQ7) ranged from 81% to 94%. Because they were near criterion, we repeated Test Set EQ4 (AE, EA) to see if the symmetry tests had facilitated these equivalence relations. They had not, so ED training was reviewed, and Test Sets EQ4 through EQ7 were repeated with results similar to the first administrations, except that the DE performances (EQ7) deteriorated somewhat. A second review of ED training still failed to produce much improvement on tests for AE and EA relations in Classes 1 and 2. At this point the subject received the following sequence of testing and training sets within one session, as shown in the bottom panel of Figure 5: (a) The AD, BD, and CD relations among stimuli that had been in first and second sequence positions were retested with Test Set OD2 (from Phase 3) four times. All performances met criterion, (b) ED training was reviewed, with consequence probabilities of 1.0, .20, and 0, (c) Test Sets EQ4 through EQ7 were repeated. Performances on tests for AE, EA, CE, and EC relations in Classes 1 and 2 (Test Sets EQ4 and EQ6) improved with repeated testing until they met criterion, and the BE and EB relations (Test Set EQ5) and the DE relations (Test Set EQ7) were demonstrated on all trials.

Phase 6: Test for Transfer of Ordinal Functions

On tests for the novel sequence E1 E2 E3 (see Table 6), the performances of both subjects were comparable to those of subjects in Experiment 1. Subject GM produced the novel sequence only once in six test trials during the first administration of Test Set TOF1, but thereafter produced it correctly on every test trial in four more administrations each of Test Sets TOF1 and TOF2. Subject CK failed to produce the novel sequence only once in four administrations of each test.

Discussion

Acquisition of four trained sequences and four trained conditional relations (ED) proceeded at about the same rate for these 2 subjects as for the subjects in Experiment 1 who had received verbal instructions to place three stimuli "in order" on sequence trials and to select the stimulus that "goes with" the comparison on match-to-sample trials. Conditional relations among stimuli that served the same functions in the trained sequences emerged for GM in similar fashion as for subjects in Experiment 1, that is, after one review of sequence training (although, unlike subjects in Experiment 1, GM did not exhibit criterion performance on the very next test set following sequence review, i.e., additional testing of conditional relations was apparently necessary for criterion performance). For CK, those relations emerged gradually during an extended first series of tests for them, without a sequencing review. In short, the training contingencies, testing procedures, and minimal instructions

were sufficient to establish four different sequences and four ordinal classes.

The most striking differences between the performances of these subjects and those in Experiment 1 came on tests for equivalence following conditional discrimination training designed to add the E stimuli to the ordinal classes. Some relations were shown on the initial tests for them; CK's performances approximated those of the instructed subjects in that all relations on tests for equivalence in the third-position and distractor classes emerged at once. Both subjects, however, required extensive review and retesting before the new E stimuli were related by equivalence to all other members of all the ordinal classes. The critical variable may have been the instruction that the subjects in Experiment 1 received, before their first reflexivity test set, to touch the first figure they saw and then ". . . touch the figure that you think goes with the first one . . ." (Instruction 4, Appendix) and a similar instruction prior to the first trial in Phase 4 in which the ED relations were trained. Subjects in Experiment 2 were instructed only to "touch" and "touch again." These minimal instructions were apparently sufficient to establish conditional responding for Subject CK, because she demonstrated many conditional relations reliably on Phase 3 tests for reflexivity and ordinal classes and learned the ED conditional relations to start Phase 5 just as quickly as the instructed subjects did. Subject GM did not show generalized identity matching, however, until identity matching had been trained. Her subsequent performance in Phases 3 and 4 was similar to that of Subject CK. If the difference in instructions was responsible for the difference in performance on the Phase 5 tests by subjects in the two experiments, it may be that the "goes with" instruction implied more than just a series of conditionally related stimuli. As Figures 4 and 5 illustrate, Subjects GM and CK usually responded in a conditional manner, typically matching the new E stimulus either with other members of the ordinal class as predicted by equivalence on every trial within a test set (e.g., E3 with A3) or with the other available stimulus on every trial (e.g., E3 with A4), producing 0% consistent with class formation. It is not readily apparent why minimal instructions and the contingencies produced this pattern of conditional responding and the combination of "goes with" instructions and contingencies produced a different pattern, but repeated exposure to the training and testing contingencies led to the same final performances by the subjects in Experiment 2 as by the instructed subjects in Experiment 1. Finally, once the E stimuli were related by equivalence to the stimuli in the respective ordinal classes, these subjects sequenced the E stimuli as they had sequenced other members of the classes without explicit instructions or reinforcement, just as their counterparts in Experiment 1 had.

GENERAL DISCUSSION

Instructions provided to human subjects in previous stimulus equivalence studies have included, among others, task demonstrations only (e.g., Sidman et al., 1982); minimal verbal instructions ("touch") to establish responding (e.g., Bush, Sidman, & de Rose, 1989); more extensive verbal instructions regarding procedures and, in some cases, stimulus relations (e.g., Saunders, Saunders, Kirby, & Spradlin, 1988); and written instructions specifying response requirements, consequences, and the interrelatedness of two types of experimental tasks (Wulfert & Hayes, 1988). Equivalence relations have emerged in most cases regardless of the nature of the instructions, even in the absence of any verbal or textual instructions. Where some form of verbal instructions has been used, however, it is not clear how they influenced the outcomes. Although interest in using the stimulus equivalence paradigm to study language appears to be growing, the potentially powerful influence of the verbal behavior of others on the development and function of equivalence classes has not been examined thoroughly. The present experiments found few differences in the performances of instructed and minimally instructed adults in their acquisition of sequence responses and conditonal discriminations and in the development of stimulus classes based on ordinal positions, but found notable differences in the devlopment of equivalence classes. This preliminary evidence suggests that the verbal behavior of another person can exert control over trained and emergent stimulus relations, but the nature of that control is not well understood.

These experiments used methods for generating equivalence classes that differed some-

what from the conditional discrimination procedures used in most stimulus equivalence work to date. Although the sequence training did not involve teaching explicit conditional discriminations among stimuli that were related ultimately by equivalence, conditional relations emerged when the subjects were exposed to two-choice match-to-sample test trials. There may have been, however, a conditional aspect to sequence training trials. Responses to specific stimuli may have been conditional on temporal order, the next vacant position in the bottom portion of the monitor screen, the stimuli available in the array in the top portion of the screen, or all of these. Our experiments were not designed to separate these possible controlling functions. It is conceivable that temporal stimuli or specific sequence positions may have served to link stimuli in the ordinal classes, much like training nodes in typical match-to-sample equivalence experiments (Fields et al., 1984).

Equivalence relations and syntax-like ordinal relations may interact in several ways. One possibility, illustrated in two previous studies (Lazar & Kotlarchyk, 1986; Wulfert & Hayes, 1988), is that conditional relations that enable equivalence are learned first; that is, grammatical classes (articles, nouns, verbs, adverbs) might be established. Then the learner can be trained to place one member of each class in one of several ordinal positions, perhaps with the specific order under the control of contextual stimuli. A large number of untrained but grammatically correct sequences (sentences) may be produced by substituting equivalent stimuli in the learned ordinal positions. The final phase of our experiments replicated the novel sequence production reported in the earlier studies, without contextual control.

Another possibility, first suggested by Lazar (1977) and explored in the present experiments, is that learning several word sequences might result in the emergence of classes of words that served a common function in the sequences. For example, after a child has learned phrases such as "the big ball," "a red car," and "an old dog," the child might demonstrate that three equivalence classes developed, containing three articles, three adjectives, and three nouns. In our experiments, 5 adults demonstrated the development of three analogous classes, as well as a class of stimuli that were excluded from sequences, after learning four different sequences.

Conclusions from the present experiments may be limited by the fact that the subjects were language proficient; in fact, all had some proficiency in two languages. Whether sequence training leads to equivalence class formation by less skilled users of language remains to be investigated. On the other hand, the sequence training procedures were sufficiently powerful to enable all 5 subjects to learn ordinal and equivalence classes and to produce a syntactically correct new sequence, despite the fact that different syntax rules probably controlled each of their first-language repertoires.

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APPENDIX

Instructions Presented to Subjects in Experiment 1

Instruction 1. For each problem, you will see several figures on the top of the screen. Your job is to put three of them in order from left to right on the bottom of the screen. Touch the figure that you think goes first. Continue until you have three figures in order on the bottom of the screen. Then touch the penny. If you have the figures in the correct order, you will hear a jingle. If the order is incorrect, you will hear a buzzer. Try to get as many correct as you can.

Instruction 2. On these problems, after you touch the penny, you will hear the jingle or the buzzer only every once in a while. Try to get as many correct as you can.

Instruction 3. There will be no jingle or buzzer after you touch the penny for any of these problems. Keep trying to get them all correct.

Instruction 4. For these problems, you will see a figure on the screen. Touch it. Then two other figures will appear, one on each side of the first one. Touch the figure that you think goes with the first one that appeared. There will be no indication as to whether your choice is correct or incorrect, so just do your best.

Instruction 5. For these problems, you will again see a figure that you should touch, and two other figures will appear. Touch the figure that you think goes with the first one that appeared. If your choice is correct, you will hear a jingle. If it is incorrect, you will hear a buzzer. Try to get as many correct as you can.

Instruction 6. While you are working on these problems, you will hear the jingle or the buzzer only every once in a while. Try to get as many correct as you can.

Instruction 7. There will be no jingle or buzzer after any of your choices on these problems. Keep trying to get them all correct.